PATENTS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Donald R. Huffman **Examiner:**

Serial No.: 08/236,933 **Art Unit:**

Filed: May 2, 1994 **Docket:** 7913ZAZY

For: NEW FORM OF CARBON

08/236,933

Assistant Commissioner for Patents
Washington, DC 20231

DECLARATION OF Harold W. Kroto UNDER 37 C.F.R. §1.132

Sir:

I, Harold W. Kroto, Ph. D., declare and say as follows:

1. I am the Royal Society Research Professor in the School of Chemistry and Molecular Sciences at the University of Sussex, Brighton, United Kingdom. I have attached for the convenience of the United States Patent Office a copy of my curriculum vitae as Exhibit 1, which describes my credentials and demonstrates my expertise in the area of fullerenes.

2. I have reviewed the above-identified application, the Preliminary Amendment therein and the following reference documents, which I understand to be cited in support of a rejection of the present application.

1. an article by K.S. Day, et al., Nature Physical Science 1973, 243, 50-51.

2. an article by Iijima, et al., in J.Phys. Chem. 1987, 91, 3466-3467. ("Iijima et al".).

3. Translation of Russian Patent No. 1,587,000.

4. U.S. Patent No. 2,957,756 to R. Bacon.

5. an article by Kappler, et al., in J. App. Phys., 1979, 50, 308-316.

3. The application teaches in clear detail to the skilled artisan the preparation of fullerenes, including C_{60}, in quantities that were never recognizably achieved before the discovery by Huffman and Kratschmer described in the application. Specifically, the application describes methods for the production of C_{60} and C_{70} in macroscopic amounts, i.e., amounts that could be seen with the naked eye (inherently at least 10^{18} molecules of product). That discovery for the first time permitted the researchers to confirm the existence and structure of these materials, including subjecting them to general testing of their detailed properties and characteristics, which had theretofore only been projected based upon educated speculation and calculation, grounded upon circumstantial evidence of their existence.

4. I am intimately familiar with the literature concerning and was personally involved in the search for C_{60} and the greater fullerene family: for convenience, one may refer particularly to our review of the literature through 1990 described in an article entitled "C_{60} Buckminsterfullerene, in Chem. Rev. 1991, 1231-1235 attached hereto as Exhibit 2 and for my personal involvement in the research effort in my article entitled " C_{60}: Buckminster-fullerene, the Celestial Sphere that Fell to Earth" in Angewandte Chemie I.E.E. 1992, 31, 111-129, attached as Exhibit 3.

5. I believe it is fair to say that I am among the recognized experts in the subject of fullerenes, and that I was quite cognizant of the state of the art in 1990, and of the early attempted preparation and identification of fullerenes, especially C_{60} and C_{70}.

6. I am familiar with the work of Huffman and Kratschmer on this subject having closely followed their research as described in the Angewandte Chemie article referred to above and attached as Exhibit 3.

7. I am also familiar with the methods described in the above-identified patent application of Huffman and Kratschmer and utilize their principles regularly in producing quantities of C_{60} for research purposes in our laboratories,

8. In my professional opinion the methods for producing the fullerenes, including C_{60}, are described in the application in such manner as to enable one skilled in the art to make and use the same.

9. In my professional opinion, the reference documents listed in paragraph 2 hereinabove, taken individually or collectively, do not teach nor do they claim to teach methods for the production of fullerenes, including C_{60}; nor is there provided evidence of the production of any such product. Specifically, it cannot be stated that there is any reliable scientific evidence of the formation of C_{60} or C_{70} in any of the references, and no assertion is made that quantities of C_{60} or C_{70} were made. In fact, any such assertion would be entirely speculative and unsupported; to my knowledge, no researcher had proven possession of C_{60} or C_{70} prior to Huffman and Kratschmer.

While Iijima et al alleges that they saw a molecule of C_{60} in the middle of a carbon particle this conclusion is similarly entirely speculative and unsupported by the evidence. Furthermore, Iijima et al did not report in that article a methodolgy capable of producing and isolating fullerenes in

10. The realization by Huffman and Kratschmer of macroscopic quantities of fullerene and the isolation and characterization of C_{60} and C_{70} by the methods described in the above-identified application is recognized by the knowledgeable scientific community as a long awaited and much needed breakthrough; it was surprising that relatively high yields of fullerene such as C_{60} could be achieved by these methods, as it was expected that no more than < 1/10000 parts of target molecules would exist in the soot product and that it would require very sophisticated equipment to isolate quantities of material required to establish and confirm the existence of the products. The difficulties that existed in the quest for C_{60} are well elaborated in the article entitled "Fullerenes" by Robert F. Curl and Richard E. Smalley, printed in Scientific American, Oct. 1991, pp. 54-62 attached hereto as Exhibit 4.

11. Although the discovery described in the Huffman and Kratschmer application may seem simplistic to the uninformed, especially in hindsight, their discovery was quite remarkable. This is readily appreciated if one considers the historical perspective. Ever since the detection of C_{60} by the collaborative efforts of the Smalley and Kroto groups in 1985, as described in the article in Nature, 1985, 318, 162-163, attached hereto as Exhibit 5, experts, such as Drs. Smalley and myself, both together and separately worked to prepare fullerenes on a larger scale. For five long years, many attempts were tried, but each were unsuccessful. Finally, to my knowledge, one group, Huffman and Kratschmer, were the first to find a methodology capable of producing and isolating fullerenes, such as C_{60}, in macroscopic amounts. This methodology is described in their application and satisfied a long felt need in this area.

12. Furthermore, one should not underestimate the significance of their discovery. For the first time, scientists were able to produce and work with samples of fullerenes. They were able to confirm the theoretical predictions about fullerenes and continue to explore new properties of same. Their discovery spawned enormous scientific interest. As a consequence, innumerable investigations and studies relating to fullerenes were conducted, generating more than four thousand publications on the subject. In short, I cannot emphasize enough that their discovery revolutionized the area of fullerenes.

13. I have been requested as well to examine the claims presented by applicants Huffman and Kratschmer. I am not qualified in the law as to the interpretation of claims; but as a scientist knowledgeable in this art, I find the qualifying terms to be aptly descriptive of the methods described and the products produced in the above-identified application, consistently with scientific usage at the time the application was filed.

14. I further assert that the term "macroscopic" aptly and correctly characterizes the breakthrough made by Huffman and Kratschmer in permitting isolation and characterization of the fullerenes C_{60} and C_{70}, in that the term expressly denotes that which can be seen (and therefore tested); that usage is consistently employed in my papers and reviews on the subject entirely independently of Huffman and Kratschmer.

15. In my professional judgement, the above-identified application adequately teaches to the skilled artisan how to make macroscopic amounts of the fullerenes including C_{60} and C_{70}; furthermore, there is ample evidence in the application that

Huffman and Kratschmer had in their possession macroscopic amounts of these products.

16. I have been among those who sought an appropriate name for this family of often co-produced structurally related material and based upon structure and the historical connection with the geodesic dome structures of Buckminster Fuller, I introduced the name of fullerenes for these molecules in 1987 which was later accepted by the scientific community fullerene by about 1990, and this has become the accepted formal name for these materials, e.g., [60] fullerene and [70] fullerene. I refer in particular to the definition I prepared for McGraw-Hill appearing in McGraw Hill Concise Encyclopedia of Science & Technology, 3rd ed. p. 819 (1994).

17. In summary, I am pleased to lend support to the applications of Huffman and Kratschmer for patent protection; as a researcher in the quest for C_{60} I can keenly appreciate the significance of the defining events reflected in the present application; I can, from my own experience, state with confidence that despite our circumstantial evidence of the existence of these molecules, the inevitable speculation and calculations of properties, and our own convictions, given our knowledge at the time, it was by no means predictable nor obvious to one skilled in the art that fullerenes, such as C_{60} or C_{70}, would be recovered in macroscopic quantities by the methods described by Huffman and Kratschmer in the above-identified application, nor to the best of my knowledge, had such results been claimed.

18. I further declare that all statements made herein of my own knowledge are true and that all statements made on information

statements and the like so make are punishable by fine or imprisonment or both under section 1001, Title 18 of United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Dated: 9 June 1995

Harold W. Kroto, Ph. D. F.R.S. PhD

236933

CURRICULUM VITAE

Harold Kroto FRS
Royal Society Research Professor

The School of Chemistry and Molecular Sciences,
The University of Sussex, Brighton, BN1 9QJ, UK

Tel 44 273 678329 direct line
44 273 606755 University main
Fax 44 273 677196 School Fax
elm kroto@sussex.ac.uk

Born 7th Oct 1939 Wisbech, Cambridgeshire, England.

Education

1947-58 Bolton School, Bolton, Lancashire.

1958-61 BSc, University of Sheffield, 1st class honours degree (Chemistry)

1961-64 PhD, University of Sheffield *Electronic Spectroscopy of Unstable Molecules*
Supervisor: R N Dixon FRS (now Professor, Bristol)

1964-65 Postdoctoral Fellow, National Research Council (Ottawa) with D A Ramsay FRS

1965-66 Postdoctoral Fellow, National Research Council (Ottawa) with C C Costain

1966-67 Member of Technical Staff, Bell Telephone Laboratories, Murray Hill, N.J.
(with Y H Pao, now at Case Western Reserve and D P Santry now at McMaster U)

University Career (University of Sussex 1967-)

1967-68 Tutorial Fellow.
1968-78 Lecturer
1978-85 Reader
1985-91 Professor
1991- Royal Society Research Professor.

Extra-university administration

SRC Millimetre Wave Telescope Sub-Committee 1977-81
SERC Millimetre Wave Telescope Users'Committee 1981-85
SERC Physical Chemistry Subcommittee 1987-90
SERC Synchrotron Radiation Facility Committee 1987-90
SERC Chemistry Committee 1988-91
IAU Sub-group on Astrophysical Chemistry 1987-
MBI Advisory Board of the Max Born Institute (Berlin) 1993-

Meeting (director, organiser or co-orgnaisor)

Brioni International Conferences 1988, 1990, 1993, ...
Royal Society Discussion Meeting 1992
Fullerene Symposium 1993 (Santa Barbara)
Cursos de Verano (El Escorial) *Fullerenos* 1994

Editorial Boards

Chemical Society Reviews 1986- (Chairman 1990-)
Zeitschrift fur Physik D (Atoms Molecules and Clusters) 1992-
Carbon (1992-)
J. Chem. Soc. Chem. Comm. (1993-)

Research Details

University of Sheffield

1961-64 PhD in Free radical spectroscopy by flash photolysis

National Research Council

1964-65 Free radical spectroscopy by flash photolysis
1965-66 Microwave Spectroscopy

Bell Telephone Laboratories

1966-67 Raman Spectroscopy of Liquids, Quantum Chemistry

University of Sussex

1967-72 Free radical spectroscopy/flash photolysis
1967-73 Liquid phase interactions/Raman Spectroscopy
1970- Unstable species/Microwave Spectroscopy
1972-90 Unstable species/Photoelectron Spectroscopy
1976- Interstellar Molecules/Radioastronomy
1983-90 Unstable species/Fourier Transform IR Spectroscopy
1985- Cluster Studies/Carbon, Metals
1990- Fullerene Chemistry, Carbon nanostructures

Temporary Appointments (Visiting Professorships etc)

1974 Visiting Associate Professor, UBC Vancouver (3 months)
1976 Visiting Scientist, NRC Ottawa (3 wks)
1978 Visiting Scientist, NRC Ottawa (3 wks)
1981 Visiting Professor, USC (3 months).
1983 British Council Visitor, Inst Rudjer Boskovic (Zagreb)
1987 CNRS (1 month) Univ Paris Sud (Orsay)
1988- Visiting Professor UCLA (Astronomy)

Extramural Activities

Sport

Tennis and Squash for Sheffield University (1959-1964).
University Athletics Union Finalists - Tennis (1962 and 1963)
President of Athletics Council, Sheffield University (1963-64)

Graphic Art, Design, Television Film

Art Editor *Arrows* Sheffield University Arts Magazine 1962-64
Winner of *Sunday Times* Book Jacket Design Competition 1963
Editor, design and layout of *Chemistry at Sussex*
featured in *Modern Publicity 1979* (international annual of Graphic Design)
Publicity and logos for Chemical Society Meetings
Logo, letterheads for Science and Engineering at Sussex

Publicity, logo, letterheads, poster for BA Meeting 1983
New Scientist BA Advertisement
Logo and letterhead for Inorganic Biochemistry Discussion Group
Logo and letterhead 1990 for *Venture Research International*
(Formerly *BP Venture Research*)
New Cover design and layout for *Chemical Society Reviews*

Chairman of Board of *VEGA SCIENCE TRUST*
Executive producer of five 1-hour Television Films of Royal Institution Discourses for Vega/BBCSelect

Miscellaneous

1981-82	Tilden Lecturer (Royal Society of Chemistry)
1990	Elected Fellow of the Royal Society
1991-	Royal Society Research Professorship
1992	International Prize for New Materials (American Physical Society, R F Curl and R E Smalley)
1992	Italgas Prize for Innovation in Chemistry
1992	Université Libre de Bruxelles (DHC)
1992	University of Stockholm (PhDHC)
1992	Longstaff Medal 1993 (Royal Society of Chemistry)
1992	Academia Europaea (Member)
1993	University of Limburg(DHC)
1994	Hewlett Packard Europhysics Prize (with D R Huffman, W Krätschmer and R E Smalley)
1994	Moet Hennessy*Louis Vuitton *Science pour l'Art* Prize

RESEARCH

Main research areas:

I Spectroscopy of Unstable Species and Reaction Intermediates
(Infrared, Photoelectron, Microwave and Mass Spectrometry)

II Cluster Science
(Carbon and Metal Clusters, Microparticles, Nanofibres)

III Fullerenes
(Chemistry, Physics and Materials Science)

IV Astrophysics
(Interstellar Molecules and Circumstellar Dust)

Research Highlights:

a) Synthesis in 1976 of the first phoaphaalkenes (compounds containing the free carbon phosphorus double bond) in particular $CH_2=PH$ (with N P C Simmons and J F Nixon, Sussex), Refs 1,7.

b) Synthesis in 1976 of the first analogues of HCP, the phosphaalkynes which contain the carbon phoshorus triple bond - in particular CH_3CP (with N P C Simmons and J F Nixon, Sussex), Refs 2,7.

c) The discovery (1976-8) of the cyanopolyynes, HC_nN (n=5,7,9), in interstellar space (with D R M Walton A J Alexander and C Kirby (Sussex) and T Oka, L W Avery, N W Broten and J M MacLeod (NRC Ottawa)), Ref 4-6, based on microwave measurements made at Sussex, Refs 3,7.

d) The discovery of C_{60}: Buckminsterfullerene in 1985 (with J R Heath, S C O'Brien, R F Curl and R E Smalley), Refs 8,13,15.

e) The detection of endohedral metallofullerene complexes (with J R Heath, S C O'Brien, Q Zhang, Y Liu, R F Curl, F K Tittel and R E Smalley), Ref 9

f) The prediction that C_{60} should be produced in combustion processes and might indicate how soot is formed (with Q L Zhang, S C O'Brien, J R Heath, Y Liu, R F Curl and R E Smalley) Ref 10

g) The explanation of why C_{70} is the second stable fullerene (after C_{60}) and the discovery of the *Pentagon Isolation Rule* as a criterion for fullerene stability in general (Refs 11,13,15)

h) The prediction of the tetrahedral structure of C_{28} and the possible stability of "tetravalent" derivatives such as $C_{28}H_4$ Refs 11,15.

i) The prediction that giant fullerenes have quasi-icosahedral shapes and the detailed structure of concentric shell graphite microparticles (with K G McKay), Refs 12,13.

j) The mass spectrometric identification and solvent extraction (with J P Hare and A Abdul-Sada) of C_{60} from arc processed carbon in 1990 - independently from and simultaneously with the Heidelberg/Tucson group; Refs 14,15.

k) The chromatographic separation/purification of C_{60} and C_{70} and ^{13}C NMR measurements which provided unequivocal proof that these species had fullerene cage structures (with J P Hare and R Taylor, Sussex), Refs 14,15.

PUBLICATIONS

180 research papers. One book "Molecular Rotation Spectra" (Wiley 1975) - reprinted with a new preface by Dover 1992.

Main Publications

1) M J Hopkinson, H W Kroto, J F Nixon and N P C Simmons, 'The detection of unstable molecules by microwave spectroscopy: phospha-alkenes $CF_2=PH$, $CH_2=PCl$ and $CH_2=PH$', *J.C.S. Chem. Comm.*, 513-515 (1976).

2) M J Hopkinson, H W Kroto, J F Nixon and N P C Simmons, 'The detection of the reactive molecule 1-phosphapropyne, CH_3CP, by microwave spectroscopy', *Chem. Phys. Letts.*, **42**, 460-461 (1976).

3) A J Alexander, H W Kroto and D R M Walton, 'The microwave spectrum, substitution structure and dipole moment of cyanobutadiyne, HC_5N', *J. Mol. Spectrosc.*, **62**, 175-180 (1976).

4) L W Avery, N W Broten, J M MacLeod, T Oka and H W Kroto, 'Detection of the heavy interstellar molecule cyanodiacetylene', *Astrophys. J.*, **205**, L173-175 (1976).

5) H W Kroto, C Kirby, D R M Walton, L W Avery, N W Broten, J M MacLeod and T Oka, 'The Detection of Cyanohexatriyne, HC_7CN, in Heiles' Cloud 2', *Astrophysics J.*, **219**, L133-L137 (1978).

6) N W Broten, T Oka, L W Avery, J M MacLeod and H W Kroto, 'The Detection of HC_9N in Interstellar Space', *Astrophys. J.*, **223**, L105-107 (1978).

7) H W Kroto, 'Semistable Molecules in the Laboratory and in Space', Royal Society of Chemistry Tilden Lecture; *Chem. Soc. Revs.*, **11**, 435-491 (1982).

8) H W Kroto, J R Heath, S C O'Brien, R F Curl and R E Smalley, 'C_{60}: Buckminsterfullerene', *Nature*, **318**(No.6042), 162-163,(1985)

9) J R Heath, S C O'Brien, Q Zhang, Y Liu, R F Curl, H W Kroto, F K Tittel and R E Smalley 'Lanthanum Complexes of Spheroidal Carbon Shells', *J. Am. Chem. Soc.*, **107**, 7779-7780 (1985).

10) Q L Zhang, S C O'Brien, J R Heath, Y Liu, R F Curl, H W Kroto and R E Smalley. 'Reactivity of large carbon clusters Spheroidal Carbon Shells and their possible relevance to the formation and morphology of soot', *J. Phys. Chem.*, **90**, 525-528 (1986)

11) H W Kroto, 'The Stability of the Fullerenes C_n (n = 24, 28, 32, 50, 60 and 70)', *Nature* 329, 529-531 (1987)

12) H W Kroto and K McKay, 'The Formation of Quasi-icosahedral Spiral Shell Carbon Particles' *Nature*, 331, 328-331 (1988)

13) H W Kroto "Space, Stars, C_{60} and Soot", *Science*, **242**, 1139-1145 (1988)

14) R Taylor, J P Hare, A K Abdul-Sada, and H W Kroto, "Isolation, Separation and Characterisation of the Fullerenes C_{60} and C_{70}: The Third Form of Carbon." *J. Chem. Soc. Chem. Commun.*, 1423-1425 (1990)

15) H W Kroto "C_{60}: Buckminsterfullerene, the Celestial Sphere that Fell to Earth", *Angewandte Chemie* **31**, 111-129 (1992)

SYMPOSIUM LECTURES and SEMINARS

Plenary/Invited Lectures

1974	Symp on High Resolution Spectroscopy (Columbus, Ohio)
1976	Symp on Molecular Structure (Austin, Texas)
1978	Faraday Society Spectroscopy Con (Bristol)
1979	14th Internat Free Radical Conf (Sanda, Japan)
	Symposium Interstellar Molecules (Meudon, France)
1980	University College Astronomy Symposium (London)
1981	Conference on Submillimetre Wave Astronomy (London)
	Advances in Spectroscopy, Faraday Meeting (London).
1983	British Association BAYS lecture (x2) (Sussex)
	Federation of Astronomical Socs, Herstmonceux
	RAS Disc Meeting on Interstellar Grains (London)
1984	Symposium on Molecular Structure (Austin, Texas)
	Microwave/IR Spectrosc of Transients (Cambridge)
	EUCHEM Reactive Species in Inorg Chem (Burghausen)
1985	High Resolution Spectroscopy Conference (York)
1986	NATO Workshop PAHs in Space (Les Houches)
	Conference on Molecular Astrophysics (Bruxelles)
	Symp on Planetary Science, Obs. de Paris (Meudon)
	Brioni Conference on Clusters (Brioni,Yugoslavia)
1987	Roy Soc Discussion on The Solar System (London)
	High Resolution Spectroscopy Symp (Dijon, France)
	Roy Soc of Chemistry Autumn Meeting (Nottingham)
	NASA Workshop on Carbon in Space (Ames CA)
1989	Internat Symp on New Aromatic Compounds (Osaka)
	Carbon Conference (Pennsylvania State)
	ACS Conference (Clusters) Miami
	Japan/UK SERC Symposium IMS (Okazaki, Japan)
	Faraday Discussion on Clusters (Warwick)
	6th ISNA Meeting (Osaka)
	Faraday meeting on Clusters (Warwick)
	19th Carbon Conference (Pennsylanvia State Univ)
1990	German Chem Soc Meeting, Organ Chem (Bad Nauheim)
	Solar System Workshop (Clemsen, North Carolina)
	IOP meeting (Warwick)
	Comet Meeting (Bad Honnef Bonn)
1991	4th Chemical Congress of North America (Fuel Science NY)
	6th Symposium on Macrocyclic Chemistry (Sheffield)
	20th Biennial Conference on Carbon (Santa Barbara)
	74th Canadian Chemistry Conference (McMaster, Hamilton)
	IOP Annual Meeting, Low Temperature Physics (Birmingham)
	Rank Prize Workshop on Molecular Cages (Lake District)
	British Association meeting BAYS lecture (Plymouth)
	Mackay Symposium (Birkbeck College)
	IAU Congress Astrochemistry (Campos de Jordao, Brazil)
	Swedish Physical Society (Stockholm)
	Fullerene Workshop (RISU, Roskilde, Denmark)
	Condensed Matter Physics 1991 (CMMP 91, Birmingham)
1992	Workshop on Atoms and Clusters 92 (Atami, Japan)
	Symp. on Atomic and Molecular Structure (Trentino)
	Portuguese Chemisty Society Meeting 1992 (Lisbon)

1st Italian Fullerene Conference (Bologna, Italy)
IOP meeting on Fullerenes (Rutherford Lab)
Universite Libre de Bruxelles Conference (Belgium)
Pittcon 92 Conference (New Orleans, USA)
American Physical Society meeting (Indianapolis)
Leermaker Symposium (Wesleyan U, Conn, USA)
Infrared Astronomy Conference (Calgary, Canada)
Adriatico Conference on Clusters (Trieste, Italy)
Invited Lecturer Cursos de Verano 92 (El Escorial)
European Materials Res Soc Meeting (Strasbourg)
IOP/RSC Joint Symposium on Fullerenes (London)
Vacuum Ultra Violet Meeting (VUV10, Paris)
11th Canadian Theoretical Chem. Conf. (Montreal)
12th Conf on Chemical Education (UCDavis, USA)
23rd European Conf, Mol Spectros (EUCMOS23, Vienna)
Symposium fur Theoretische Chemie (Blixen, Italy)
Gordon Conference on Clusters (Irsee, Germany)
Italgas Chemistry Prize Lecture (Turin)
University of Helsinki (Spec Lect) (Finland)
Gordon Combustion Conf (Spec Lect) (Hawaii)

1993 Italian Fullerene/Superconductivity Meeting - Pisa
Croatian Chemical Society Symposium - Zagreb
Fullerene/Superconductivity Meeting - Kirchberg
ACS Meeting (Fullerenes) - Denver
Sydney Leach Symposium - Paris
Theoretical Symposium - Namur
NATO Fullerene Workshop - Crete
Centenary Conf of Norwegian Chemical Society - Oslo
Fullerenes 93 Symposium - Santa Barbara
IURCAM Conference - Tokyo
Solid State Devices Conference - Tokyo
Span/American Inorg Chem Conf - Santiago (Spain)
Brioni International Conference - Brioni
Materials Conference - Wroclaw (x2)
Spanish Materials Conference - Oviedo
ACOLS Conference - Melbourne (x2)
London Schools Science Symposium

1994 Association of Science Education Conference (Birmingham)
New Organic Materials Conference (Madrid)
Science Research Institute Inaugural Meeting (Salford)
Student Chemical Society Centenary Meeting (Sheffield)
Berzelius Dagarna (Stockholm)
European Physical Society - Hewlett Packard Prize Lecture (Madrid)
Sussex University Science Teachers Conference (Sussex)
World Affairs Conference (Boulder, Colorado) (x2)
Cluster Workshop (Ameland, Netherlands) (x4)
3rd Workshop on Advances in Phys Chem (Nanjing, China)
Cursos de Verano Fullerene Workshop (El Escorial, Spain)
LVMH Science pour l'art Prize lecture (Paris, France)
Gordon Conference (Ceramic Materials) New Hampshire (special lecture)
Materials Research Soc Meeting (Boston)

Named/Special Lectureships

1992 Probst Lecture - Southern Illinois Univ (USA)

1993 Cherwell-Simon Lecture (Oxford)
Steinhofer Lecture (Kaiserslautern)

Dreyfus Lecture (UCLA)
John Coffin Memorial Lecture (University of London)
30th Anniv Lecturer (Chinese Univ of Hong Kong)

1994 Brode Lecturer (Whitman College, Washington, USA)
Winegard Lecturer (Guelph University, Ontario, Canada)
Kolthoff Lecturer (University of Minnesota, USA)
Rayleigh Lecturer (Harrow School
Chemical Inst of Canada Lecturer (Sherbrook University, Quebec, Canada)
Distinguished lecturer (University of Kentucky, Center for Applied Energy Research)

1995 Werner Lecturer (Trinity College, Dublin)
Tizard Lecturer (Westminster, School)

Research Seminars (Overseas)

1974 Bell Telephone Labs (NJ), NRC (Ottawa), UBC (Vancouver)
1976 Paris Sud (Orsay), Harvard, NRC (Ottawa)
1977 Lille, Brussels, Montreal, Waterloo
1978 Cal. State (L.A.), Cal Tech.(Pasadena), Arizona (Tucson), USC(Los Angeles), Herzberg Institute (NRC, Ottawa), UC Berkeley
1979 UBC (Vancouver), Montreal
1980 IBM (San Jose), UC Santa Barbara, USC (Los Angeles), Chemical Society Zurich
1981 UC Berkeley
1982 Trinity College (Dublin), NRC. (Ottawa)
1983 Basel, Kiel, Giessen, Inst.Rudger Boskovic (Zagreb)

1985 ETH (Zurich), Basel, Inst. R. Boskovic (Zagreb), Rice Univ. (Houston), Texas A&M, Texas Tech.

1986 Harvard, Guelph-Waterloo, Aachen (Tech Hochschule), Chicago

1987 USC (Los Angeles), UCLA (Astron), Berkeley, JPL (Pasadena)

1988 UCLA(Chem), Stanford, Arizona(Tucson), Arizona State (Tempe), Tech. Hochschul (Darmstadt), Max Planck Inst (Martinsried)

1989 MPI (Munich), UCLA(Chem), Oregon, JPL(Pasadena), Berkeley, NASA (Moffett Field), Toronto, Montreal, Guelph.

1991 California (Los Angeles, UCLA), California (Berkeley), Cal Tech (Pasadena), California (Santa Barbara, UCSB), Belo Horizonte (Brazil), Recife (Brazil), Erlangen, Freigburg, Heidelberg, Shell (Amsterdam), NIST (Washington) NRC (Ottawa), Arizona(Tucson)

1992 Pisa (Italy), Michigan (Ann Arbor, USA), Chicago (USA), McGill (Montreal, Canada), Chemical Society of Zurich, Laue Langevin Laboratory (Grenoble), Aarhus (Denmark), Helsinki (Finland), Niels Bohr Inst(Copenhagen), Stockholm (DHc lecture), Tokyo (Japan), Shinshu (Nagano, Japan), Kitagawa Industries (Tokyo Japan), Nobeyama Radio Observatory (Japan), NRC (Ottawa, Canada)

1993 Basel Chemical Society, ULB Bruxelles (DHC lecture), Josef Stefan Institute (Ljubljana), Limburg (DHC lectures), UC San Diego, Crete, NEC Japan, Shinshu, Shizuoka, Materials Institute (Warsaw), Milan, Berlin Chemical Society

1994 2xRSC (Belgium section) lectures (Brussels) (1 British School), Swedish Royal Academy (Stockholm), Stockholm University (Physics Dept), Herzberg Inst NRC Ottawa, Braunschweig, Scherring (Berlin), Humboldt Univ Berlin, Bielefeld, KFA (Julich), Peking U x2 (Beijing), Bell Labs NJ, UNAM Mexico City, UCLA (Astronomy)

1995

UK Research Seminars (* > 1)

Sussex (Chemistry, Physics, Astronomy, Biology*), Cambridge* (Chemistry and Astronomy Depts), Southampton*, Oxford*, Reading*, Nottingham*, Sheffield*, Warwick*, Glasgow, Strathclyde, East Anglia, Coleraine, Manchester*, Edinburgh*, Birmingham*, U.C. London* (Chemistry and Astronomy), Bristol*, ICI*, Surrey.

UK General Lectures for Students and Public (Chemistry/Astronomy)

Southampton*, Reading*, Sussex*, Exeter*, Bristol*, Bath, Surrey, Essex, Imperial College*, University College*, Cardiff*, Kent, Swansea, U.C.North Wales, Portsmouth, Leicester*, Loughborough, Thames, Durham, Leeds*, Nottingham*, Open University, Cambridge*, RSC (Sheffield) RSC (Cumberland), Brighton Astron. Soc.*, Eastbourne Astron.Soc., Croydon Astron. Soc., Alembic Club (Oxford), U.C. Sussex(Astron, Biology) Q.M.C*. Sussex Town and Gown, Mid-Kent Astronomy Society, Royal Institution (Friday Evening Discourse), East Midlands RSC.

1993 Bath, Cambridge, Imperial College, Birmingham, Warwick Royal Society, Nottingham, Liverpool, Pfizer Company,
1994 Leicester, Aston, Royal Institution (Friday Evening Discourse (#2)), Sussex, East Anglia, Surrey
1995 Durham, Liverpool, Queen's (Belfast), Coleraine

Schools'Lectures

Christ's Hospital School, Worthing Sixth Form College, Kingston Polytechnic (Schools Lecture), RSC Schools L RSC Essex Schools Lecture, Chelsea College, Charterhouse, London Schools (Q.M.C.), King's School Canterbury, St Dominics 6th form College Harrow, Dreyfus Schools' Lectures, 1986 at RoyalInstitution, St Paul's School for Girls Open Day Lectures (Sussex), Hurstpierpoint College BAYS Lecture(Southampton)

BROADCAST INTERVIEWS etc

1976 BBC Radio (Science Now) "Interstellar Chains"
1977 BBC Radio World Service "Interstellar Chains"
1979 BBC TV OU Film based on my lecture "Chemistry between the Stars"
1985 BBC Radio World Service "Chemistry in Space"
1985 BBC Radio Sussex "Chemistry in Space"
1986 BBC (Science Now) "C60,Buckminsterfullerene"
1989 USA Local Radio Carbon in Space)
1991 BBC Radio programme - "Science Now"
1992 BBC Radio World Service (x2)
1992 BBC TV "Molecules with Sunglasses" Horizon
1992 RAI TV Interview for Italian Television (Premio Italgas)
1992 NDR TV Nord Deutsche Rundfunk Programme on Fullerenes
1993 SFB Radio - Sender Freies Berlin, Radio
1993 UCLA video film Dreyfus Lecture
1994 BBC Select TV - Royal Institution Lecture

RESEARCH GRANTS

1970	Microwave Spectroscopy	(SRC)	10 000
1974	Microwave Spectroscopy	(SRC)	24 000

1974	Microwave Spectroscopy	(Sch)	10,000
1978	Photoelectron Spectroscopy (with M F Lappert)	(SRC)	18,000
1979	Computer	(SRC)	20,000
1977	PDF (with J F Nixon)	(SRC)	18,000
1977	Astronomy (with T Oka)	(NATO)	2,500
1981	Infra Red Spectroscopy	(SERC)	72,000
1980	Quad Mass Spectrometer	(RS)	5,000
1983	IR spectroscopy	(SERC)	20,000
1986	Jet Cooled i.r.spectroscopy	(SERC)	33,000
1987	Clusters (with A J Stace)	(SERC)	157,000
1992	Fullerene Chemistry with R Taylor/ D R M Walton	(BP/ICI/SERC)	200,000
1992	Cluster Rolling Grant with AJ Stace/J N Murrell)	(SERC)	300,000

MAIN RESEARCH COLLABORATION

The value of microwave and photoelectron techniques to a wide area of chemistry has been highlighted by fruitful collaboration with colleagues here at Sussex. One important research project carried out with D R M Walton involved the synthesis and study of long chain polyynes. This work led to our detection this species in interstellar space by Radioastronomy carried out with T Oka and astronomers at the Herzberg Institute for Astrophysics, NRCC Ottawa. A project, carried out with J F Nixon has opened up a new field of organophosphorus chemistry. Work has been carried out in collaboration with J P Maier (Basle) to study the ions of unstable molecules is now in progress. Cluster Beam studies on Carbon with R F Curl and R E Smalley (Rice). Astronomy Research has been carried out with M Jura at UCLA. The present Sussex Programme on Fullerene Chemistry is being carried out in collaboration with R Taylor and D R M Walton.

ASSOCIATED RESEARCH PERSONNEL

35 D.Phil students,
10 Chemistry by Thesis students
12 Postdoctoral Fellows.

POPULAR PRESS COVERAGE

Interstellar Molecule Discoveries,

Ottawa Citizen, The Times, The New York Times, New Scientist, Scientific American

Unstable Phoshorus Molecules:

New Scientist

Fullerenes

New York Times (x2), The Daily Telegraph, Houston Chronicle, New Scientist, C&E News, Omni, Sky and Telescope, Science Now, Economist, Der Spiegel, Time, Daily Telgraph.....

TEACHING EXPERIENCE

Lecture Courses (Sheffield University)

(1961-1963) taught O-level Chemistry at Sheffield Technical College

Lecture Courses (University of Sussex 1968-)

Chemistry Highlights Lectures for Freshers
1st and 2nd year Spectroscopy courses
Structural Methods (2nd year course)
Symmetry (2nd year)
Advanced Structure (3rd year course)
Valence Theory for Biochemists (2nd year course).
Rotational Spectroscopy (3rd year option)
Astrophysical Chemistry (3rd year option)
Topics in Chemical Physics (3rd year course)
High resolution Techniques (graduate course)

Lecture Courses (Univ. of Southern California, Los Angeles, 1981)

Chemistry & Spectroscopy of Interstellar Molecules

Seminars and Tutorials (Sussex)

Atomic and Molecular Structure (1st year course).
Mechanistic Principles (1st and 2nd year courses).
Thermodynamics (1 year course).
Conceptual Models (3rd year option course).
Synthesis (1st year course).
Statistical Mechanics

Practical Courses (Sussex)

1st year Introductory Practical Chemistry
2nd year Physical Chemistry (organiser 1978-80)
3rd year Chemistry and Chemical Physics Projects.

ADMINISTRATIVE POSITIONS

University of Sussex

Chairman of the University Safety Committee (1986-7)
School Undergraduate Admissions Organiser (1973-1976).
Chemistry by Thesis Sub-Board (1975-1978), Sec (1976-78).
Chemical Physics Subject Group, Secretary (1974-76), Chairman (1976-82 85-87).
Chemical Physics Sub-Board, Secretary (1974-76) Chairman (1979-83, 85-87)
School Joint Committee (1973-74, 77), Chairman (1974)
White House Careers Weekend (Weekend Residential Seminar Course on Careers for 3rd year students), Organiser (1974)
Editing, design and layout of "Chemistry at Sussex" School, Teaching and Research Handbook (copy available). The cover design was reproduced in "Modern Publicity", a major international annual of the best in graphic art and design
School Chemical Society Lecture Organiser (1987-)
University Senate (1979-1980).
Science Committee (1980, 1981-2, 1985-7)
Laboratory Director (1983-86): Overall responsibility for Tech Staff logistics, deployment, grading etc; School research strategy, budgeting, expenditure, building and laboratory space allocation.